EXPENDABLE TIDE GAUGE

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LONG-TERM GOALS

This work's main goal is development of an expendable, small, easily-deployed, long lifetime, and low cost tide gauge that will increase water level data collection capabilities in littoral regions for scientific purposes (e.g. determination of regional tidal model forcing inputs and model validations) and for Naval tactical oceanographic warfare applications (e.g. amphibious and mine countermeasures operations).

SCIENTIFIC OBJECTIVES

The main objective is to develop a suitable bottom-resting tide gauge that measures water levels from which astronomical tidal variations, non-astronomical water level variations, and wind-wave characteristics can be determined. Although subsequent operational Naval applications are an important goal, measurements should be useful for purposes such as studying coastal water level spatial variability, forcing and validating regional tidal models, enabling water level and tidal predictions at locations where tides are not usually measured, providing shallow water wind-wave information, driving surf zone wave models, and providing reference datums for remote sensing depth measurements that are not near existing tide stations.

APPROACH

The approach is to use a low cost solid-state pressure sensor that is calibrated as a function of measured pressure and temperature (measured by a thermistor) and a very low-power microprocessor (operating at 3.3 Vdc) that can operate for many months with common batteries. C language software separates and processes data for water levels and wind-waves. By means of within gauge data analysis, data are compressed into results for internal storage in non-volatile flash memory or transmission via RS-422 interface (to permit long cable runs if needed) to a PC (with attached RS-422 to RS-232 converter), data logger, or data relay device (e.g. radio modem). Alkaline "D" cells power the gauge for between 4.5 and 21 months depending on whether 0.5 hr or 1.0 hr data collection intervals are used and whether tide mode or tide with wave mode operation is selected. Data are sampled at 2.0 Hz and digitally filtered so that low frequency data provide non-wind-wave water level changes and high frequency data provide non-directional wind-wave spectra and wave parameters (when gauges are used in shallow water). Wave records presently consist of 2048 samples corresponding to a length of 17.07 min or 4096 samples corresponding to a length of 34.13 min. Water level averaging times are selectable between 1 min and 20 min. Fabricated gauges weigh

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10 lbs (in air with batteries) and are packaged in a PVC pressure case approximately 13" long by 4.5" diameter. The gauges were designed so that they would be small enough to be air-deployed in an A-sized sonobuoy, or smaller, configuration. Mark Giardina is the Senior Engineer for this effort.

WORK COMPLETED

Before FY97, possibly applicable measurement and analysis techniques were reviewed, gauge specifications were developed, a test chamber was designed and built, pressure sensors were evaluated, and preliminary electronic boards were designed and tested. During FY97, limited data were collected with a test gauge at the U.S. Army Corps of Engineers and National Data Buoy Center (NDBC) Test Facility at the Field Research Facility (FRF) pier, Duck, NC. Electronic board design and software development was completed. Four gauges were built and deployed with five Seabird wave and tide gauges during the Joint Task Force Exercise (JTFEX) as part of a Naval Research Laboratory-Stennis Space Center (NRL-SSC) project. The gauges and their data were retrieved during September. Draft system documentation and a draft users manual were written. These gauges, the final documentation, and results of the FTFEX tests will be delivered to the Navy (NRL-SSC) this calendar year.

RESULTS

The four gauges that will be delivered to NRL-SSC for further testing and use in tidal modeling research were completed and used in a Navy exercise with other gauges to provide validation data. All gauges were recovered and data appear reasonable. This experience shows that the concept of an expendable tide gauge is valid and that it should be feasible to build such gauges (in reasonable quantities) to expand locations where water levels and wind-waves are measured for scientific and operational Naval applications. A question to be examined is whether this technology is suitable for high accuracy applications such as determination of datums for charting and navigation.

IMPACT/APPLICATION

By enabling water level measurements to be made more easily and at lower cost, expendable tide gauges should provide important data for driving and testing tidal models and for quantifying high water level spatial variability that may occur in shallow water littoral regions. Gauge features should make transition of the technology to operational Naval use attractive.

TRANSITIONS

Plans call for the delivered gauges to be used by NRL-SSC to demonstrate this technology's usefulness for tidal modeling research. Gauge development was planned for later transition to operational Naval use to directly benefit tidal modeling along data sparse foreign coasts and to support military operations by providing low cost water level, tide, and wind-driven wave data.

RELATED PROJECTS

NRL-SSC tidal modeling efforts will use the delivered gauges. Data collected during JTFEX also

supported NRL-SSC's Surf Zone Environmental Representation Program that is sponsored by the Defense Modeling and Simulation Office (DMSO). This program is coupling a suite of state-of-the-art deep water through surf zone surface wave models that will be validated using the measured data. Neptune Sciences is also investigating techniques to quantify water level spatial variability for optimizing tide station network design under sponsorship of the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) and the Navy through NRL-SSC. This research has demonstrated improved prediction capabilities of nonlinear (chaotic) signal processing techniques (e.g. Frison et al., 1997a, 1997b) that could be utilized with measurements made by the gauges.

REFERENCES

Frison, T.W., Abarbanel, H.D.I., Earle, M.D., and Scherer, W.D., Chaos and Predictability in Tide and Water Level Measurements, submitted for publication, under review, 1997a.

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